

Achievable Performance and Effective Interrogator Design for SAW RFID Sensor Tags

Abstract

For many NASA missions, remote sensing is a critical application that supports activities such as environmental monitoring, planetary science, structural shape and health monitoring, non-destructive evaluation, etc. The utility of the remote sensing devices themselves is greatly increased if they are “passive” – that is, they do not require any on-board power supply such as batteries – and if they can be identified uniquely during the sensor interrogation process. Additional passive sensor characteristics that enable greater utilization in space applications are small size and weight, long read ranges with low interrogator power, ruggedness, and operability in extreme environments (vacuum, extreme high/low temperature, high radiation, etc.) In this paper, we consider one very promising passive sensor technology, called *surface acoustic wave* (SAW) *radio-frequency identification* (RFID), that satisfies all of these criteria.

In general, RFID is a method of identifying items using radio waves to interrogate “tags” encoded with a unique identifier that are affixed to the items of interest. In the case of passive tags, only the interrogator, which transmits power to the tags in the form of radio-frequency electromagnetic radiation, requires access to a power supply. Passive RFID technologies are used today in many applications, including asset tracking and management, security and access control, and remote sensing. To date, most of the development and application in RFID technology has focused on either asset/inventory tracking and control or security and access control because these are the largest commercial application areas. Recently however, there has been growing interest in using passive RFID technology for remote sensing applications, and SAW devices are at the forefront of RFID sensing technology development.

Although SAW RFID tags have great potential for use in numerous space-based remote sensing applications, the limited collision resolution capability of current generation tags limits the performance in a cluttered sensing environment. That is, as more SAW-based sensors are added to the environment, numerous tag responses are superimposed at the receiver and decoding all or even a subset of the telemetry becomes increasingly difficult. Background clutter generated by reflectors other than the sensors themselves is also a problem, as is multipath interference and signal distortion, but the limiting factor in many remote sensing applications can be expected to be tag mutual interference. This problem may be greatly mitigated by proper design of the SAW tag waveform, but that remains an open research problem, and in the meantime, several other related questions remain to be answered including:

- What are the fundamental relationships between tag parameters such as bit-rate, time-bandwidth-product, SNR, and achievable collision resolution?
- What are the differences in optimal or near-optimal interrogator designs between noise-limited environments and interference-limited environments?
- What are the performance characteristics of different interrogator designs in term of parameters such as transmitter power level, range, and number of interfering tags?

In this paper, we will present the results of a research effort aimed at providing at least partial answers to all of these questions.